A floristic inventory and preliminary vegetation classification of the mixed semi-evergreen rain forest in the Minkébé region, North East Gabon

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ABSTRACT
This study describes the floristic diversity and vegetation of the Minkébé area in North East Gabon, an area hitherto poorly known. A total area of 290 ha was completely surveyed for trees > 70 cm dbh. A detailed inventory for trees > 10 cm dbh of a 3 ha plot was conducted. Many new records could be added to the existing checklist. Spatial distribution of the major species is presented as well as a preliminary vegetation typology. Attention is given to the ecological and successional status of the tree species with special emphasis on *Gilbertiodendron dewevrei*. Comparisons are made with data on forest composition in Gabon from various authors.

KEY WORDS
Floristic inventory,
Minkébé,
Gabon,
rain forest,
Gilbertiodendron.

RÉSUMÉ
La diversité floristique et la végétation de la région de Minkébé au Nord-Est du Gabon, une région très peu connue jusqu'à maintenant, sont étudiées. Une surface totale de 290 ha a été complètement explorée pour des arbres > 70 cm dbh. Un inventaire détaillé des arbres > 10 cm dbh a été également réalisé sur une surface de 3 ha. Beaucoup d'espèces ont été ajoutées à la liste systématique existante. La distribution spatiale des espèces dominantes est présentée, de même qu'une typologie préliminaire de la végétation. La position écologique et sylvigénétique des espèces arborescentes est signalée en accordant une attention spéciale à *Gilbertiodendron dewevrei*. Des comparaisons sont effectuées avec les données fournies par plusieurs autres études traitant de la composition forestière au Gabon.

MOTS CLÉS
Inventaire floristique,
Minkébé,
Gabon,
forêt ombrophile,
Gilbertiodendron.

INTRODUCTION

This paper presents part of the results of the floristic and vegetation inventories of a multi-disciplinary study in the Minkébé area, North East Gabon, within the framework of the WWF program for Gabon.

Information on the vegetation of North East Gabon is rather scarce. According to WHITE (1983) the forests of Gabon are part of the Guineo-Congolian regional centre of endemism. The forest in the North East of Gabon belongs to the mixed moist semi-evergreen Guineo-Congolian forest type (WHITE 1983). Though the prevalent vegetation is moist semi-evergreen forest of mixed composition, small islands of single-dominant forest are also found scattered throughout. The upper stratum of single-dominant forest is uniform and dense, usually 35-45 m high and is composed of a single or very few species.

According to CABALLÉ (1978) two vegetarion types can be distinguished in eastern Gabon. The first one called "forêt dense à tendance semi-caducifoliée" with *Pycnanthus angolensis*, *Pentaclethra eetveldeana*, *Terminalia superba* and *Triplochiton scleroxylon*. The second type called "forêt dense humide sempervirente" with *Scyphocephalum ochocoa*, *Pycnanthus angolensis*, *Pentaclethra eetveldeana*, *Celtis spp.*, *Gilletiodendron pierreanum* and *Gilbertiodendron dewevrei*. The last species forms single-dominant forest islands. The quanrirative importance of Burseraceae, Irvingiaceae, and Olacaceae is far less than in the west of the country (e.g. absence of okoumé, *Aucoumea klaineana*), whereas rhe importance of Mimosaceae and Papilionaceae increases towards the east of Gabon.

In 1966 a forest inventory was carried our in the Bélinga mountains 50 km southeasr of the Minkébé area (AUBRÉVILLE 1967; HALLÉ et al. 1967). REITSMA (1988) gives a derailed quantirative ecological inventory of four one-hecrare plots of undisturbed lowland forest in Gabon. One of his plots is located at Ekobakoba, south of Bélinga and southeast of Makoukou (Fig. 1). Floristically Notth Easr Gabon has been described in 6 checklists (HALLÉ 1964, 1965; HALLÉ & LE THOMAS 1967, 1970; HLADIK & HALLÉ 1973; FLORENCE & HLADIK 1980).

METHODS

FIELDWORK

The basecamp was situated on a high bank of the Sing river, at 1°30'N, 12°48'E. A line survey was conducted with an orientation of 80 grads and 280 grads (Fig. 1). Within the transect two surveys were carried out, one of trees > 70 cm dbh (diameter at breast height measured at 1.3 m above ground or immediately above the buttresses if these extend beyond 1.3 m) and a second concerning trees > 10 cm dbh. The fieldwork was carried out in 1990.

The survey of rrees > 70 cm dbh comprised an area with a rotal length of 58 km and was 50 m wide (surface area 290 ha), divided into 500 × 50 m sections. The location of every tree > 70 cm dbh was mapped, the diameter measured and if neccesary a voucher specimen was collected for identification.

The survey of trees > 10 cm dbh comprised a transect of 6 km length and was 5 m wide (surface area 3 ha), divided in 100 × 5 m sections. The locality of every tree > 10 cm dbh was mapped, the diameter measured and if neccesary a voucher specimen was collected for identrification. In addition also all plants, including herbs and shrubs, beating flowers and/or fruits ptesenr on the transect wete collected to get an impression of the floristic divetsity. An additional florisric survey was carried out along rivets and streams.

DATA PROCESSING

The voucher specimens and a complete set of all fertile herbarium specimens were sent to Wageningen (Herbarium Vadense) for identificarion. The fitst ser of ferrile herbarium specimens is present at the Herbier National CENAREST, Libreville. A complete listing of the species can be found in VAN VALKENBURG (1990) and in STEEL (1992).

For all species found a diameter class disttibution was made and the location of main species along the ttansect drawn on scale.

In ordet to asctibe an impottance value to a family or species the relative frequency of that family or species was determined by the following formula.

$$\text{Relative frequency} = \frac{\text{number of individuals of a taxon}}{\text{total number of individuals}} \times 100\%$$

The quantitative data gathered in the vegetation survey were used for a preliminary classification of the forest vegetation. For the vegetation analysis each section was treated as a relevé. Not only the absence or presence of species was taken into account but also the abundance. The number of individuals was transfered into the following classes: absent = –, 1-2 trees = 1, 3-4 trees = 2, 5-6 trees = 3, 7-8 trees = 4, > 8 trees = 5.

These data were processed using a computer cluster programme TWINSPAN (HILL 1979) and adapted by the former Department of Vegetation Science, Plant Ecology and Weed Science. Twinspan is a polythetic divisive cluster programme. The polythetic method means that divisions are made based upon all species present in the relevés, and the abundance of species is also taken into account. The resulting clusters were analysed and interpreted before well defined vegetation types could be distinguished. With the computer programme Clutab, a synoptic table was prepared, giving frequencies on a scale of 5 of each species per cluster.

After a typology of the vegetation of the 500 m as well as the 100 m plots was made, the large and the small plots were combined and compared. Using field observations, the data on diameter distribution of the various tree species,

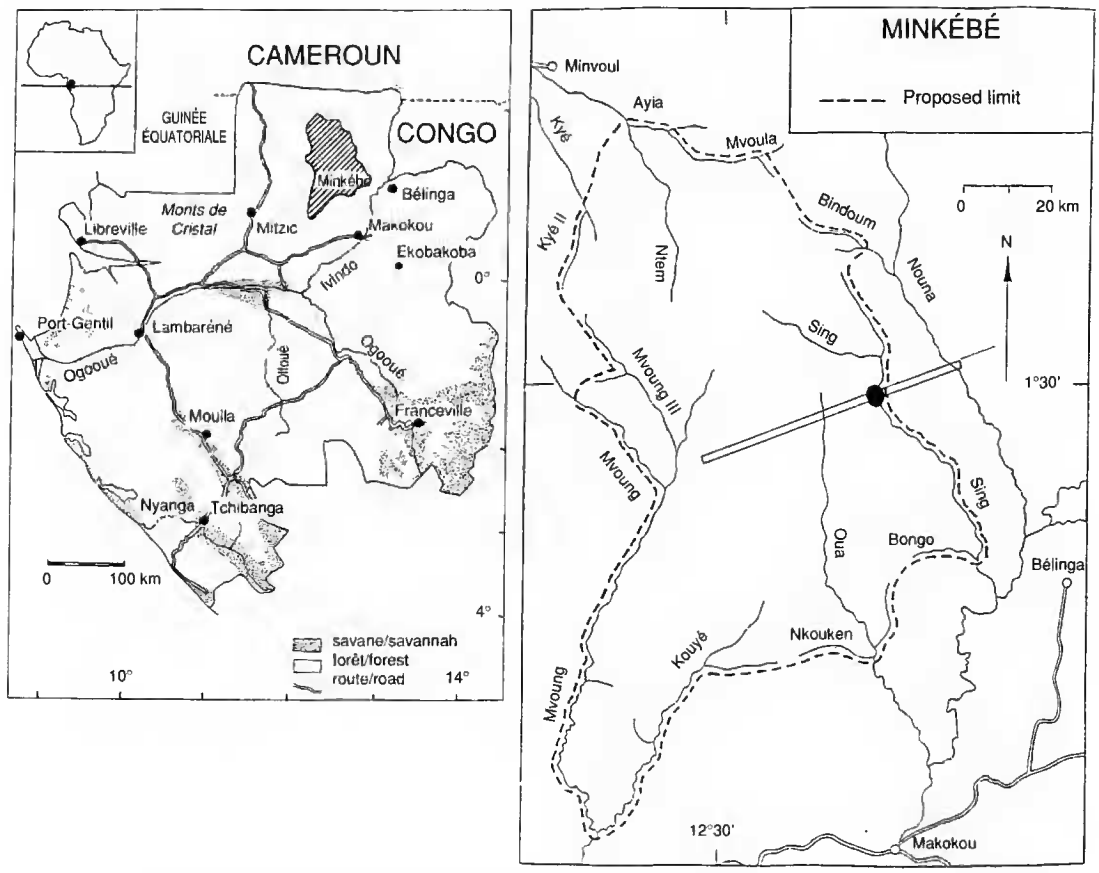

Fig. 1.—Map of Gabon with the location of the various research sites (adapted from REITSMA 1988).

diameter distribution within plots, scarce data from literature about ecological requirements of certain tree species (e.g., CABALLÉ 1978; GÉRARD 1960; SAINT AUBIN 1963; WHITE & ABERNATHY 1996) and their status in the successional process, insight in the forest dynamics was attempted.

RESULTS

FLORISTIC DIVERSITY

The floristic survey of the two transects in the Minkébé area, including riversides and a general collecting of flowering and/or fruiting plants, resulted in 655 taxa identified to species level in 89 families (VAN VALKENBURG 1990; STEEL 1992). Many specimens could only be identified to genus or family level; 214 new taxa could be added to the existing checklist for North East Gabon (HALLÉ 1964, 1965; HALLÉ & LE THOMAS 1967, 1970; HLADIK & HALLÉ 1973; FLORENCE & HLADIK 1980). An additional collecting trip in December 1990 has added another 3 species to this list of new records, although still a considerable number of specimens has to be identified (Appendix 1).

The survey of trees > 70 cm dbh (totalling 290 ha) comprised a total of 1148 individuals of 113 species in 34 families. The three most important families are Caesalpiniaceae (27.1%), Mimosaceae (20.9%), Burseraceae (7%).—Fig. 2. The ten most common species are *Dacryodes buettneri*, *Distemonanthus benthamianus*, *Erythrophleum ivorense*, *Gilbertiodendron dewevrei*, *Monopetalanthus pellegrinii*, *Cylicodiscus gabunensis*, *Pentaclethra eetveldeana*, *Piptadeniastrum africanum*, *Pycnanthus angolensis*, and *Pterocarpus soyauxii*, followed by *Alstonia boonei*, *Terminalia superba*, and *Petersianthus macrocarpus*.

The survey of trees > 10 cm dbh (totalling 3 ha) comprised a total of 1155 individuals of 202 species in 45 families. The three most important families are Caesalpiniaceae (28.7%),

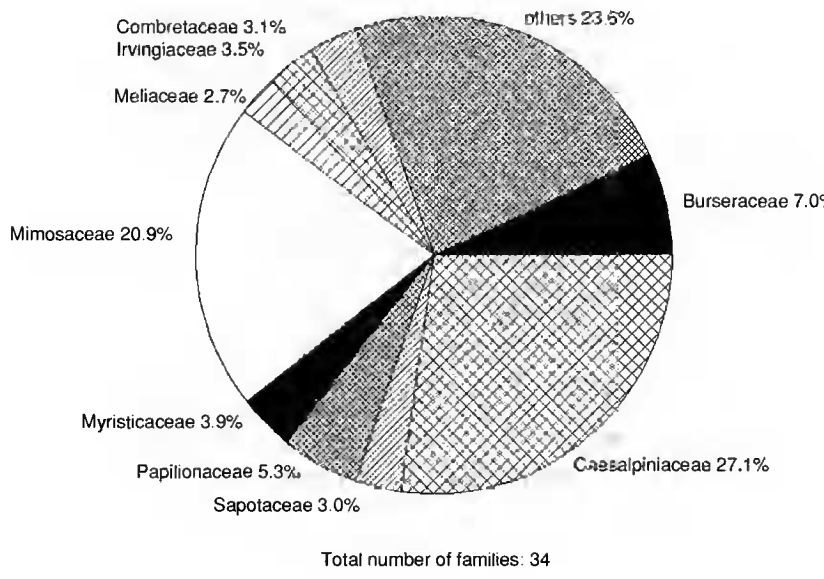

Fig. 2.—Family importance (as percentage of total individuals) of **trees > 70 cm dbh** in a line survey of 290 ha in the Minkébé area.

Euphorbiaceae (9%), Burseraceae (7%).—Fig. 3. The ten most common species of medium or small size are *Polyalthia suaveolens*, *Santiria trimera*, *Cryptosepalum congolanum*, *Plagiosiphon multijugus*, *Scorodophloeus zenkeri*, *Centroplacus glaucinus*, *Dichostemma glaucescens*, *Plagiostyles africana*, *Coula edulis*, and *Cola rostrata*.

From the tree inventory it is clear that some species do not occur as big trees with dbh > 70 cm in the 500 m relevé, but are restricted to the 100 m plots as smaller individuals. One example is *Gilbertiodendron ogouense*. This species can be considered as understorey species, never reaching great height or diameter. These smaller trees provide a means of subdividing the vegetation types defined by the larger trees.

Various other species may be considered as typical understorey species, such as *Cola rostrata*, *Coula edulis* and, *Santiria trimera*. Therefore the species composition of the 10 cm diameter plots is not representative of the upper canopy.

Species which occur in all diameter classes such as *Gilbertiodendron dewevrei*, *Santiria trimera* and, *Cola rostrata* can be considered as primary species.

The diameter disrriburion and sparial distribution of these common species (Fig. 4) illustrate their differences in stature and ecological preferences. The porential stature of the species decreases from *Gilbertiodendron dewevrei* to *Cola rostrata*. Whereas *Gilbertiodendron dewevrei* and *Cola rostrata* are mutually exclusive, *Santiria trimera* is found in association with both species.

Ecological preferences can be discerned in the survey of large diameter trees (Fig. 5). *Pterocarpus soyauxii* and *Cylicodiscus gabunesis* are common species, the latter found in slightly higher densities. *Gilbertiodendron dewevrei* and *Monopetalanthus pellegrinii* have a very well defined distribution and are mutually exclusive. *Dacryodes buettneri* has a rather local disrriburion but can be found in high densities. *Terminalia superba*, a good indicator for late secondary forest, also occurs very locally with high densities.

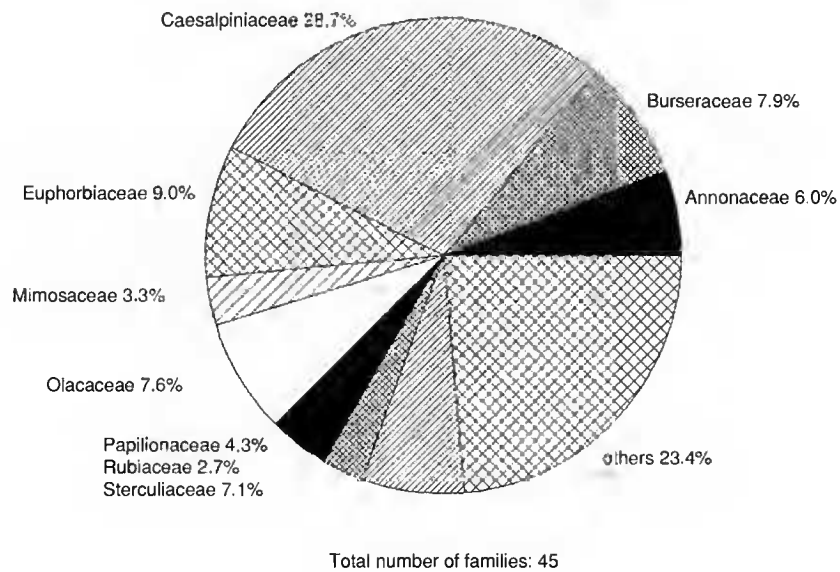

Fig. 3.—Family importance (as percentage of total individuals) of **trees > 10 cm dbh** in a line survey of 3 ha in the Minkébé area.

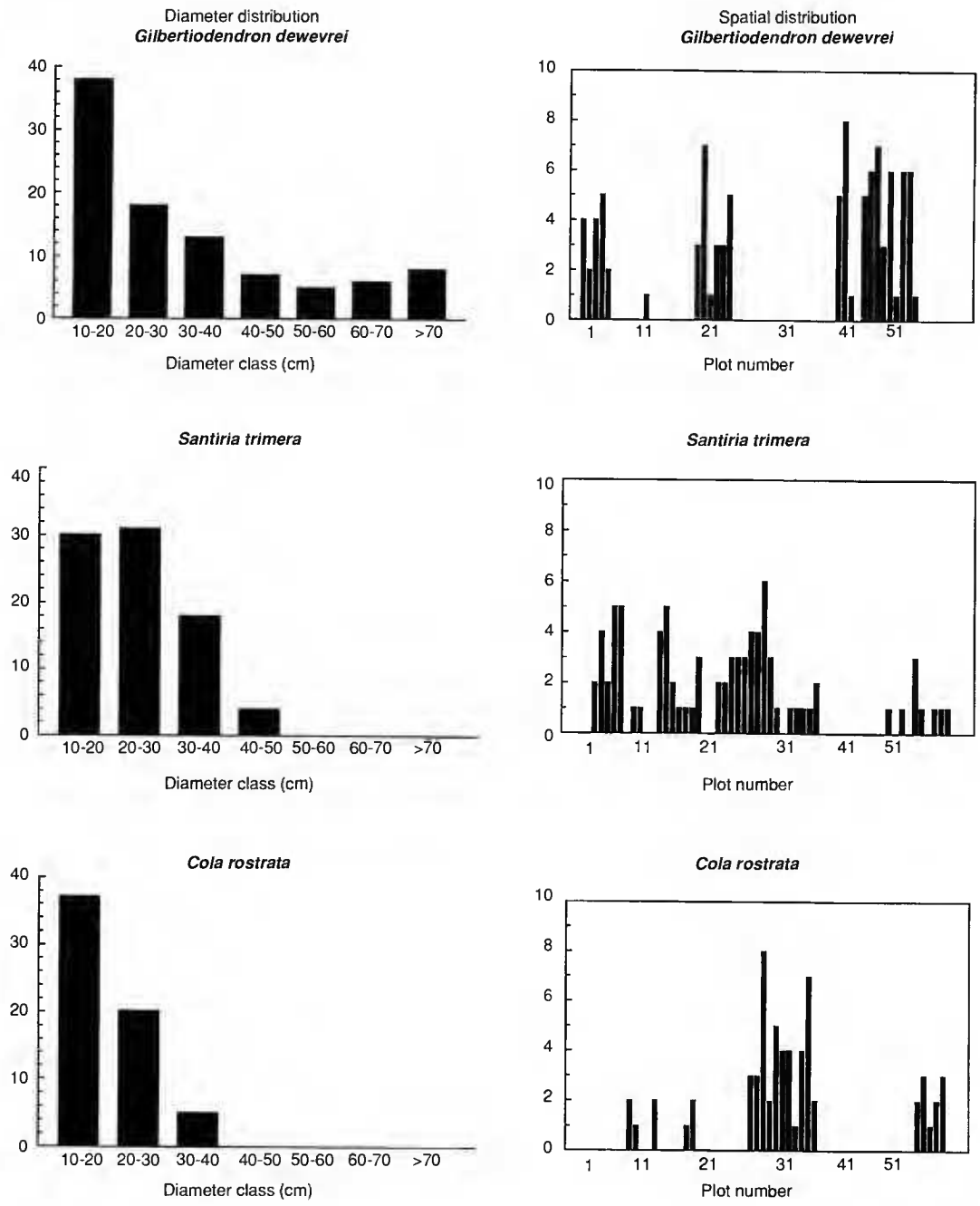

Fig. 4.—Diameter distribution and spatial distribution of three common tree species (per 100 x 5 m plot) along the 6 km transect of trees > 10 cm dbh: *Gilbertiodendron dewevrei*, *Santiria trimera*, and *Cola rostrata*. (*y*-axis: number of trees).

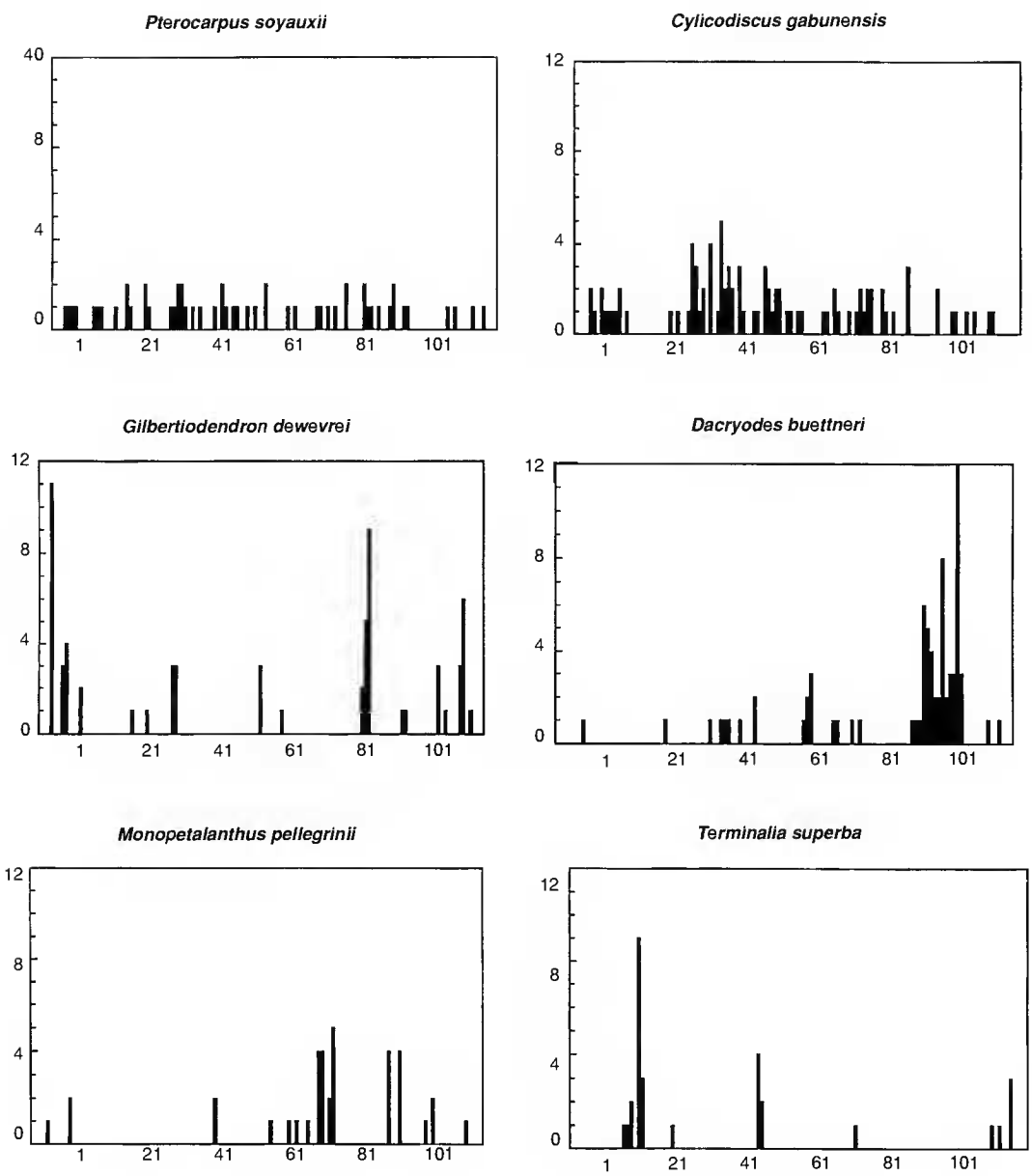

Fig. 5.—Spatial distribution of some characteristic tree species (per 500 × 50 plot) along the 58 km transect of trees > 70 cm dbh: *Pterocarpus soyauxii*, *Cylicodiscus gabunensis*, *Gilbertiodendron dewevrei*, *Dacryodes buettneri*, *Monopetalanthus pellegrinii*, and *Terminalia superba*. (*x*-axis: plot number; *y*-axis: number of trees).

Description of the vegetation types

The name of each vegetation type is based on two species of which one is a more common with highest frequency class, and the second is either a differential or an accompanying species. A differential species is differential for a cluster if its frequency is at least 30% (= one frequency class) higher than in any other cluster, or two related clusters (Schaminée et al. 1995). Occasionally a species was considered differential when it occurred in a frequency of 20% higher than in any other cluster.

When no differential species were present or no clear dominant species the second most important species was taken to name the type.

Typology of the 500 m length plots

In total 115 plots of 500 × 50 m were sampled (one plot was empty). The number of relevés used for clustering is 101 as all the relevés with fewer than 5 individual trees of > 70 cm dbh (n = 14) were not included.

From the ordered Twinspan table five main clusters can be distinguished. These can be described in terms of frequency and relative abundance of the species present and treated as vegetation types. Table 5 presents the synoptic table of the discerned clusters and vegetation types.

Type A: *Gilbertiodendron dewevrei - Pterocarpus soyauxii* type (11 relevés).
This type is very characteristic because of the high frequency of *Gilbertiodendron dewevrei* with high average abundance. In fact *Gilbertiodendron* is the only characteristic species. *Oxystigma buchholzii* occurs in this type only, but with low frequency. In general this type is poor in species (average 5.2). In comparison with all the following types *Cylicodiscus gabunensis* and *Erythrophleum ivorense* are virtually absent.

Type B: *Dacryodes buettneri - Baillonella toxisperma* type (21 relevés).
This type is characterised by the high occurrence of *Dacryodes buettneri* and relatively high presence of *Baillonella toxisperma* (highest frequency class of all types), both differential species. Common species with relatively high frequency are *Cylicodiscus gabonensis*, *Piptadeniastrum africanum* and *Erythrophleum ivorense*. Some species occur more in this type than the others, such as *Fagara heitzii*, and *Testulea gabonensis*. *Parkia bicolor* occurs slightly more frequently than in A and D.

Type C: *Monopetalanthus pellegrinii - Cylicodiscus gabunensis* type (27 relevés).
This type is less clearly defined than the latter and the following type. *Monopetalanthus pellegrinii* is the differential species of this type and is abundant. *Monopetalanthus letestui* occurs in this type with highest frequency and is slightly differential.

Type D: *Cylicodiscus gabunensis - Pycnanthus angolensis* type (34 relevés).
This type has no differential species, but *Pycnanthus angolensis* as well as *Distemonanthes benthamianus* are almost confined to this type and the next. *Cylicodiscus gabunensis* occurs with high frequency, but *Monopetalanthus* is absent. *Gambeya lacourtiana* and *Uapaca paludosa* are present mainly in this type. Average number of species is higher than in the previous types.

Type E: *Terminalia superba - Ceiba pentandra* type (8 relevés).
This type is characterised by four differential species, three with high frequencies (highest of all types) and relatively high abundance i.e. *Terminalia superba*, *Alstonia boonei* and *Ceiba pentandra*, and *Celtis adolfi-friderici*. The common species which occur in A, B, C and D are present in this type, but all with low frequency. *Pycnanthus angolensis* is present with higher frequency, but with slightly lower average abundance than in type D. *Blighia welwitschii* and *Mitragyna stipulosa* are confined to this type, and may also be considered as differential.

Typology of the 100 m length plots

In total, 59 plots of 100 × 5 m were sampled (one plot was empty). From the ordered Twinspan table 4 vegetation types could be distinguished, two of which have subtypes. The frequencies of each species in the relevés of each (sub)type are given in Table 6.

Type 1 (cluster 1 + 2): *Gilbertiodendron dewevrei - Gilbertiodendron ogoouense* maintype (22 relevés).
This type is characterised by the high frequency as well as abundance of *Gilbertiodendron dewevrei* and relatively high frequency (40-60%) of *Gilbertiodendron ogoouense*, both differential species for clusters 1 and 2. This type can be divided into two subtypes namely:
1.a: subtype with *Oxystigma buchholzii* and *Cryptosepalum congolanum* (12 relevés).
Oxystigma buchholzii, *Cryptosepalum congolanum*, *Treculia africana*, *Plagiosiphon multijugus* and *Uapaca heudelotii* are differential species for this type, compated with all other types. There are hardly any common species in this subtype.
1.b: subtype with *Santiria trimera* and *Lasiodiscus marmoratus* (10 relevés).
Lasiodiscus marmoratus is differential for this subtype and *Santiria trimera* is frequent, both are absent in the previous one. Typical species are *Heisteria parviflora*, *Strombosia scheffleri*, *Baphia spp.* On average this subtype has a higher number of species than subtype 1.a (13.0 vs. 9.5), but all with low frequencies.

Type 2 (cluster 3): *Calpocalyx dinklagei - Grewia coriacea* type (4 relevés).
This type is based on only four relevés and it is therefore doubtful whether it can be considered as a separate type, although it has five differential species: *Calpocalyx dinklagei*, *Grewia coriacea* as well as *Xylopia quintasii*, *Anthonotha macrophylla* and *A.* cf. *ferruginea*. A large number of species is present only in this type, but all with low frequencies (21-40%). In contrast to the next types the common species *Cola rostrata*, *Petersianthus macrocarpus*, *Plagiostyles africana* and *Strombosia pustulata* do not occur.

Type 3 (cluster 4 + 5): *Cola rostrata - Petersianthus macrocarpus* maintype (21 relevés).
This type is characteristed by its high frequency of *Cola rostrata*. *Scorodophloeus zenkeri* also occurs very frequently, as well as *Strombosia pustulata* and *Petersianthus macrocarpus*. This type can be divided into two subtypes:
3.a: subtype with *Coula edulis* (10 relevés).
In this subtype *Polyalthia suaveolens* and *Coula edulis* are very frequent. *Centroplacus glaucinus* is absent contrary to subtype 3.b.
3.b: subtype with *Strombosia pustulata* (11 relevés).
Strombosia pustulata and *Plagiostyles africana* occur more frequent and abundant in this type than in subtype 3.a. *Dichostemma glaucescens* can locally be abundant (4 plots). In this subtype *Polyalthia suaveolens* and *Coula edulis* are poorly represented in comparison with subtype 3.a.

Type 4 (cluster 6): *Santiria trimera - Centroplacus glaucinus* type (12 relevés).
This type is characterised by the presence of *Centroplacus glaucinus* and *Scorodophloeus zenkeri* with highest frequencies of all types. There are no differential species for this type. *Polyalthia suaveolens* and *Plagiostyles africana* occur also frequently. *Cola rostrata* and *Petersianthus macrocar-*

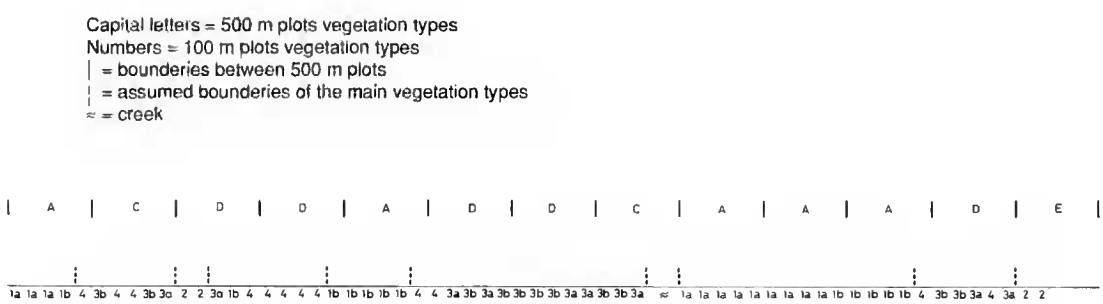

Fig. 6.—A schematic presentation of the occurrence of the 500 m and 100 m vegetation types in the Minkébé survey.

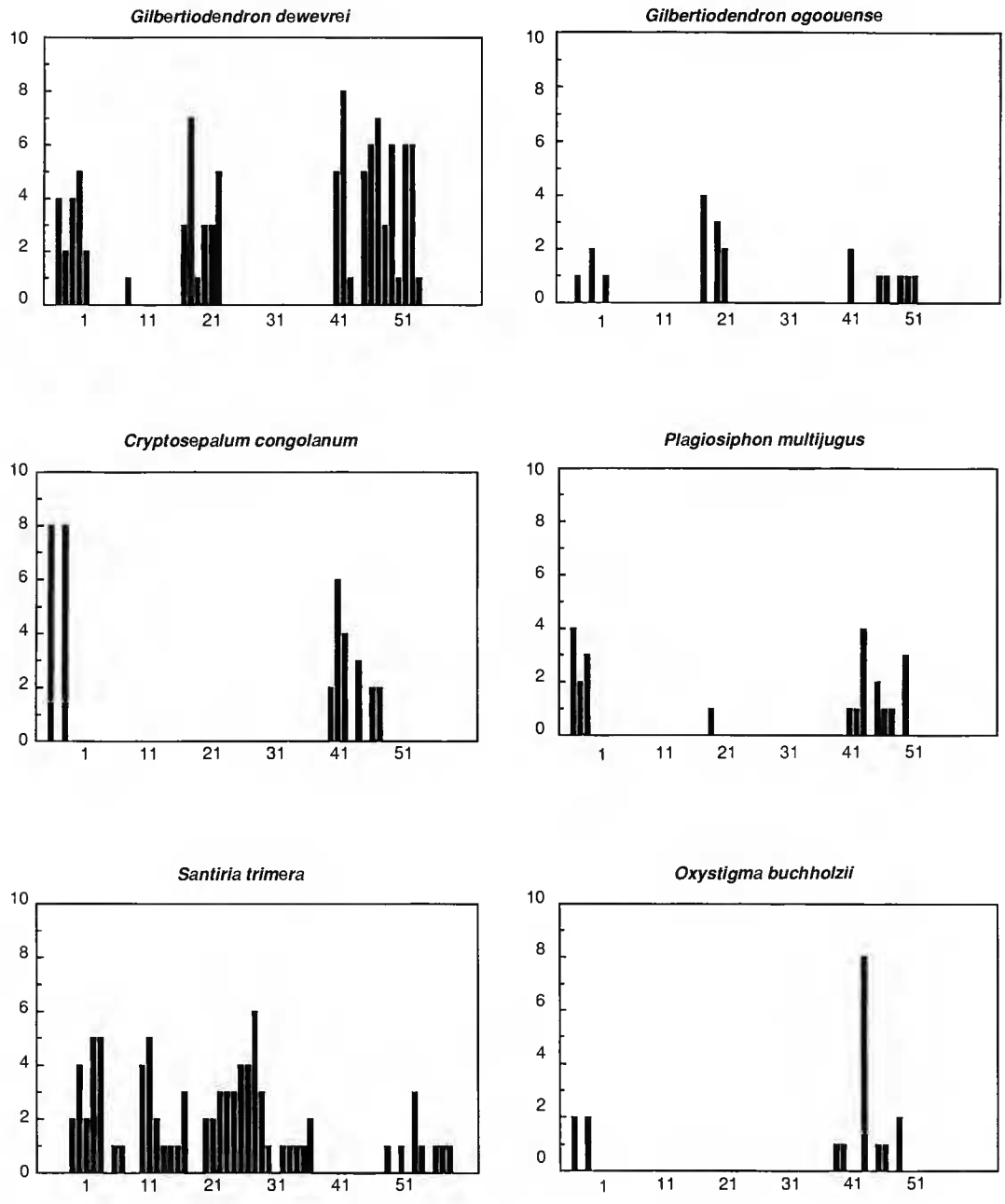

Fig. 7.—Spatial distribution of some characteristic tree species (per 100 × 5 m plot) along the 6 km transect of trees > 10 cm dbh: *Gilbertiodendron dewevrei*, *Gilbertiodendron ogoouense*, *Cryptosepalum congolanum*, *Plagiosiphon multijugus*, *Santiria trimera*, and *Oxystigma buchholzii*. (*x*-axis: plot number; *y*-axis: number of trees).

pus are poorly represented, compared to type 3.a and 3.b, with which type 4 shows great similarity.

Combination of 500 m plots with the 100 m plots

Figure 6 gives in schemaric form the occurrence of the 500 m and 100 m types in the transect. Combining the types derived from the small plots with those from the large plots we see some striking features.

Type 1.a and 1.b coincide with main type A. This type now can clearly be subdivided into a *Gilbertiodendron dewevrei* type with *Oxystigma buchholzii* and a *Gilbertiodendron* type without *Oxistygma*, whereby rhe first type occurs close to rhe streams and the latter on somewhat drier places adjacenr.

The ecological preferences of some smaller species occurring in the two subtypes of the *Gilbertiodendron* maintype are illustrated in Figure 7. *Gilbertiodendron dewevrei* and *G. ogooueense* are found in both wet and dry habitats, *Cryptosepalum congolanum* and *Plagiosiphon multijugus* are only prescnt in thc wet habitat and *Oxystigma buchholzii* is confined to the permanently inundated sites along the river. Contrary to this *Santiria trimera* is only present in thc drier land habitat.

Type A is clearly primary forest; of the constituting species all diameter classes are represented, forming large almost monospecific patches.

There are no smaller plot types which coincidc with type B, but from thc large trce inventory alone type B can be classified as primary forest, because of absence of clear secondary species.

Type C and type D are closely related types. The main difference is that D shows more signs of former disturbances through the occurrence, in higher frequencies and/or higher abundance of a number of secondary species, such as e.g. *Pycnanthus angolensis, Distemonanthus benthamianus, Petersianthus macrocarpus*. The abundance of *Cylicodiscus*, one of the main primary species in C and D, is almost equal.

This difference is also reflected in the types 3.a, 3.b as well as type 4, which are also very related to each orher, all three corresponding with types C and D. Types 3.a, 3.b and 4 represent development stages of forest growth from secondary to primary, type 4 having already more primary species with higher abundance than 3.a; while in type 3.a the primary species occur in higher frequency and slightly more abundant than in 3.b.

There arc no smaller plot types which coincide with type B, but from the large tree inventory alone type B can be classified as primary forest, because of absencc of clear secondary species.

Type 2 of which only 4 relevés are present seems to coincide mainly with E (3 out of 4 relevés) and slightly with D. The large size *Terminalia superba, Ceiba pentandra* and *Eribroma oblongum* indicate that type E may be classified as late secondary forest. The presence of *Anthonotha macrophylla* and *Xylopia quintasii* in the 100 m plots indicates that the forest is changing into primary forest.

As there probably are more changes taking place in the composition of smaller trees than in thc large trees it is difficult to show very strict correlations between the types of the 100 m plots and the 500 m plots.

DISCUSSION

The data on family and species importance of trces > 70 cm dbh can be compared with the data of CABALLÉ (1978) concerning trees > 60 cm dbh (see Table 1 + Table 2).

Comparing the data on family importance of large trees from CABALLÉ (1978) with the Minkébé results, the importance of Caesalpiniaceae is (almost) the same, Mimosaceae are more important in the Minkébé survey, but Myristicaceae importance is much lower (Table 1). If we compare the importance of the tree species (Table 2), the absence of *Scyphocephalum ochocoa* in the Minkébé survey is noticeable and this explains also the low importance value of Myristicaceae. The higher value for *Piptadeniastrum africanum* and *Cylicodiscus gabunensis* in Minkébé accounts for the higher importance value of Mimosaceae. Though the relative frequency of Caesalpiniaceae is the same, the share of the constituting species differs. *Gilletiodendron pierreanum* is absent in the Minkébé survey, and *Distemonanthus benthamia-*

TABLE 1.—Comparison of family importance of large trees in the Minkébé area (290 ha) with the results of CABALLÉ (1978) for East Gabon. Values in % of total number of trees.

	CABALLÉ * dbh > 60 cm**	Minkébé dbh > 70 cm
Caesalpiniaceae	26.7	27.1
Burseraceae	4.2	7.0
Irvingiaceae	2.6	3.5
Olacaceae	2.4	
Mimosaceae	14.6	20.9
Papilionaceae	3.1	5.3
Myristicaceae	8.5	3.9

*: Based on the 15 most abundant species.
**: Based on all individuals of all species present.

nus, *Erythrophleum ivorense* and *Monopetalanthus pellegrinii* are not among the 15 most important species of CABALLÉ (1978).

The data on family and species importance of trees > 10 cm dbh can be compared with the data of CABALLÉ (1978) concerning trees 20 cm < dbh < 60 cm (see Table 3 + Table 4).

The family importance value of small and medium sized trees (Table 3) shows an extremely high value for Caesalpiniaceae in the Minkébé survey (when compared to CABALLÉ). This is caused by the fact that 23 of the 59 relevés (39%) are located in *Gilbertiodendron* forest, whereas in the survey of trees > 70 cm dbh only 11 of the 104 relevés (11%) are located in *Gilbertiodendron* forest. Comparing the relative frequency values of CABALLÉ (1978) with the Minkébé data, the difference in importance value of Caesalpiniaceae is illustrated with the higher value of *Gilbertiodendron spp.* and the 5 additional Caesalpiniaceae species in Minkébé (Table 4).

The data of the survey of trees > 10 cm dbh can also be compared with the results of REITSMA at Ekobakoba (REITSMA 1988), which is most proximate to the Minkébé area. REITSMA's one-hectare plot, on the top of a small hill with little variation in relief, comprised 438 individuals > 10 cm dbh, 85 species in 30 families. The three most important families are also Caesalpiniaceae, Euphorbiaceae and Burseraceae.

According to REITSMA (1988, table 9, page 46), who uses importance values, the ten most important species are *Hymenostegia pellegrinii*, *Scyphocephalum ochocoa*, *Santiria trimera*, *Dialium pachyphyllum*, *Plagiostyles africana*, *Desbordesia glaucescens*, *Dacryodes buettneri*, *Cola rostrata*, *Polyalthia suaveolens*, and *Entandrophragma candollei* (a single tree only).

The average density of trees > 10 cm dbh in the Minkébé area is 385 trees per ha, which is less than in REITSMA's Ekobakoba site, who found 438 individuals in one hectare. This can be attributed to the fact that part of the survey was situated in the dynamic river system of the river Sing. The higher number of species found cannot only be attributed to the larger area surveyed, but is surely also caused by the greater environmental diversity, since swamps, periodically flooded forest and dry forest are included in the survey.

The high value for *Hymenostegia pellegrinii* in the Ekobakoba plot and its absence in the Minkébé survey of trees > 10 cm is another example of local dominance of certain Caesalpiniaceae species. The high value is also caused by the small sample size/area surveyed. REITSMA's plot is a 100 × 100 m plot with little

TABLE 2.—Comparison of species importance of large trees for the 15 highest ranking species in the Minkébé area (290 ha) with the results of CABALLÉ (1978) for East Gabon. Values in % of total number of trees.

	CABALLÉ dbh > 60 cm	Minkébé dbh > 70 cm
Scyphocephalum ochocoa	5.2	
Pentaclethra eetveldeana	4.5	3.7
Gilletiodendron pierreanum	4.2	
Pycnanthus angolensis	3.3	3.7
Petersianthus macrocarpus	3.1	2.7
Alstonia boonei	3.0	2.6
Dacryodes buettneri	2.9	6.5
Piptadeniastrum africanum	2.9	4.2
Cylicodiscus gabunensis	2.6	7.9
Celtis brieyi	2.5	
Gilbertiodendron sp.	2.4	5.6
Pterocarpus soyauxii	2.3	4.8
Uapaca sp.	2.3	1.1
Scorodophloeus zenkeri	2.0	1.1
Terminalia superba	2.0	2.5
Distemonanthus benthamianus		3.5
Erythrophleum ivorense		5.3
Monopetalanthus pellegrinii		2.3

TABLE 3.—Comparison of family importance of small and medium sized trees in the Minkébé area (3 ha) with the results of CABALLÉ (1978) for East Gabon. Values in % of total number of trees.

	CABALLÉ * 20 cm < dbh < 60 cm	Minkébé ** dbh > 10 cm
Euphorbiaceae	8.1	9.0
Caesalpiniaceae	9.3	28.7
Burseraceae	6.9	7.9
Mimosaceae	5.0	3.3
Annonaceae	3.3	6.0
Lecythidaceae	3.1	
Ulmaceae	2.3	
Olacaceae	2.0	7.6
Myristicaceae	2.8	
Pandaceae	1.2	

* : Based on the 15 most abundant species.
**: Based on all individuals of all species present.

variation in relief. The Minkébé survey is a three ha plot of 6000 × 5 m with much more variation in topography and abiotic factors. The chances for local dominance over the entire plot are much smaller. CABALLÉ's surface area covers vast stretches of the eastern zone of Gabon and therefore high species importance values are impossible.

When comparing family importance values of trees > 60 cm dbh with 20 cm < trees < 60 cm of CABALLÉ (1978) it is clear that Caesalpiniaceae and Mimosaceae are very important canopy trees (41.3%) but are far less prominent (14.4%) among small and medium sized trees (the floristic composition of small and medium sized trees is more diverse).

The recognized vegetation types of the 500 m as well as 100 m plots show the internal dyna-

TABLE 4.—Comparison of species importance of small and medium sized trees for the 15 highest ranking species in the Minkébé area (3 ha) with the results of CABALLÉ (1978) for East Gabon and REITSMA (1988) at Ekobakoba (1 ha). Values in % of total number of trees.

	REITSMA * dbh > 10 cm	Minkébé dbh > 10 cm	CABALLÉ 20 cm < dbh < 60 cm
Plagiostyles africana	5.3	1.8	8.1
Scorodophloeus zenkeri		5.0	6.4
Santiria trimera	5.3	7.2	5.8
Pentaclethra eetveldeana		1.4	3.9
Polyalthia suaveolens	3.3	2.9	3.2
Petersianthus macrocarpus		1.6	3.1
Celtis brieyi			2.3
Coula edulis		3.5	2.0
Scyphocephalum ochocoa	3.3		1.4
Dialium pachyphyllum	4.6		1.7
Coelocaryon preusii			1.4
Gilbertiodendron dewevrei		8.2	1.3
Gilbertiodendron ogoouense		1.7	
Panda oleosa			1.2
Pentaclethra macrophylla			1.1
Dacryodes buettneri	2.0		1.1
Desbordesia glaucescens	2.5		
Entandrophragma candollei	0.3		
Hymenostegia pellegrinii	7.6		
Cola rostrata	4.6	5.4	
Centroplacus glaucinus		1.9	
Cryptosepalum congolanum		3.0	
Dichostemma glaucescens		2.3	
Oxystigma buchholzii		1.6	
Plagiosiphon multijugus		2.0	

*: 10 most important species according to REITSMA's importance value.

TABLE 5.—Synoptic table of the vegetation types of the 500 m plots (trees dbh > 70 cm) of the Minkébé area (for codes see below).

Cluster	1	2	3	4	5
Vegetation type	A	B	C	D	E
Number of relevés	11	21	27	34	8
Aver. no. of species	5.2	7.9	7.8	9.0	7.9
Standard deviation	2.7	3.2	2.4	2.9	3.3
Differential species					
Gilbertiodendron dewevrei	V	I	+	I	-
Oxystigma buchholzii	II	-	-	-	-
Baillonella toxisperma	I	III	+	I	-
Monopetalanthus letestui	I	I	II	-	-
Monopetalanthus pellegrinii	-	I	III	-	-
Dacryodes buettneri	II	IV	II	II	-
Alsonia boonei	I	I	I	II	IV
Pycnanthus angolensis	-	I	-	III	IV
Terminalia superba	-	-	I	I	IV
Distemonanthus benthamianus	-	-	I	III	IV
Gambeya lacourtiana	-	-	-	II	I
Celtis adolfi-friderici	-	-	-	I	II
Xylopia hypolampra	-	-	+	I	II
Ceiba pentandra	-	-	-	-	III
Blighia welwitschii	-	-	-	+	II
Mitragyna stipulosa	-	-	-	-	II
Common species					
Petersianthus macrocarpus	-	I	I	II	II
Pentaclethra eetveldeana	I	II	I	II	III
Pterocarpus soyauxii	III	I	III	III	I
Erythrophleum ivorensis	I	III	III	III	II
Cylicodiscus gabunensis	I	III	IV	III	-
Hymenostegia pellegrinii	II	I	I	I	-
Piptadeniastrum africanum	II	III	III	II	-
Irvingia grandifolia	I	-	I	I	II
Guibourtia tessmannii	I	I	-	I	-
Parkia bicolor	I	II	-	I	-
Fagara heitzii	-	II	I	I	-
Scorodophloeus zenkeri	I	I	+	I	-
Millettia laurentii	-	+	I	-	II
Klainedoxa gabonensis	-	I	I	I	I
Pentaclethra macrophylla	-	I	II	II	-
Celtis tessmannii	-	I	I	II	-
Other species (excluding rare)					
Amphimas pterocarpoides	-	-	+	I	I
Beilschmiedia sp.	-	-	I	+	I
Uapaca paludosa	-	I	-	II	-
Detarium macrocarpum	I	-	I	I	-
Anopyxis klaineana	-	+	I	I	I
Celtis mildbraedii	I	-	+	I	I
Canarium schweinfurtii	-	+	+	I	-
Coula edulis	-	I	I	-	-
Dialium pachyphyllum	-	I	I	-	-
Dialium dinklagei	-	I	+	+	-
Erismadelphus exsul	-	I	I	I	-
Fillaeopsis discophora	-	I	I	I	-
Entandrophragma cylindricum	I	-	+	I	-
Entandrophragma candollei	-	+	I	I	-
Parkia filicoidea	-	+	I	+	-
Irvingia gabonensis	-	-	+	I	I

Milicia excelsa	-	-	+	+	I
Lophira alata	I	-	-	-	I
Syzygium sp.	-	I	-	I	I
Dracaena mannii	-	+	-	I	I
Nauclea diderichii	-	+	I	I	-
Pterygota bequaertii	I	-	-	I	-
Tessmannia africana	I	+	-	+	-
Tessmannia anomala	I	-	I	-	-
Tetraberlinia bifoliolata	I	-	+	I	-
Turraeanthus africanus	I	-	-	I	-

Rare species

Afzelia bipindensis: D,+; *Albizia adianthifolia*: B,+; D,I; *Albizia ferruginea*: D,I; *Antiaris africana*: B,+; *Antrocaryon micraster*: B,I; C,+; *Bombax bunoponense*: A,I; D,I; *Coelocaryon preussii*: D,+; *Crudia gabonensis*: B,+; D,+; *Dacryodes igaganga*: C,+; *Daniellia oblongum*: C,+; *Desbordesia glaucescens*: B,I; *Diogia zenkeri*: C,+; *Drypetes gossweilleri*: C,+; *Entandrophragma congoense*: C,I; *Eribroma oblongum*: C,+; D,I, *Ficus elasticoides*: D,+; *Gambeya beguei*: C,+; D,+; *Guarea thomsonii*: D,I; *Gilbertiodendron ogooense*: B,+; *Heisteria parvifolia*: E,I; *Julbernardia seretii*: C,+; *Kayodendron bridelioides*: D,+; *Klainedoxa trillesii*: C,+; D,I; *Landolphia foretii*: C,+; *Lovoa trichiloides*: A,I; B,I; *Macaranga* sp.: A,I; *Mammea africana*: A,I; *Maranthes glabra*: B,I; *Maranthes* sp.: B,+; C,+; *Myrianthus arboreus*: E,I; *Newtonia glandulifera*: C,+; *Newtonia* cf. *glandulifera*: B,+; *Oldfieldia africana*: B,+; C,I; *Ongokea gore*: B,I; C,I; *Parinari excelsa*: B,+; C,+; *Pachyelasma tessmannii*: B,+; *Panda oleosa*: C,+; D,I; *Pteleopsis hylodendron*: C,+; D,I; *Pterygopodium oxyphyllum*: B,I; D,+; *Rhodognaphalon brevicuspe*: C,+; *Scottellia klainei*: D,I; *Staudtia gabonensis*: D,I; *Stemenocoleus micranthus*: B,I; *Strombosia scheffleri*: C,+; *Testulea gabonensis*: B,I; C,+; *Tieghemella africana*: B,+; *Trichilia tessmannii*: C,I, *Trichoscypha acuminata*: B,+; *Tridesmostemon omphalocarpoides*: C,+; *Uapaca heudelotii*: B,+.

Frequencies in 5 classes

-	= species not present in the relevés of the cluster
+	= species present in 1-5% of the relevés
I	= species present in 6-20% of the relevés
II	= species present in 21-40% of the relevés
III	= species present in 41-60% of the relevés
IV	= species present in 61-80% of the relevés
V	= species present in 81-100% of the relevés

mics of the forest, with young and old stages alternating over short and long distances (Fig. 6). As the inventory took place along a transect with adjacent plots it could be expected that the typology would be less pronounced. Figure 6 shows the borders between each sample plot. On the basis of the typology the assumed boundaries between the different vegetation types are drawn.

More data are needed before something can be said about the successional status of the different types (Type D either a transitory type having elements of Type A or transitory to E, having various species in common with E). It also contains fewer individuals and fewer species in comparison with the other types. It is either not yet completely developed to mature forest or in a degraded phase.

As little was recorded about the soil and the local topography, not much can be said about the ecology of the vegetation types, except for the *Gilbertiodendron dewevrei - Oxystigma* subtype, which occurs primarily along streams and is inundated. Medium size trees are *Oxystima buchholzii* and *Plagiosiphon multijugus*. The *Gilbertiodendron dewevrei - Santiria trimera* forest, on drier places, has a canopy dominated by *Gilbertiodendron dewevrei*, but *Oxystigma* is absent, while medium trees include *Santiria trimera*, *Strombosia scheffleri*, *Coula edulis* and *Carapa procera*.

The vegetation types described in this study are but local types of which the syntaxonomic significance can only be determined if far more relevés from nearby regions become available. Ecological parameters such as soil characteristics, hydrology, local topography and human influen-

TABLE 6.—Synoptic table of the vegetation types of the 100 m plots (trees > 10 cm) of the Minkébé area (for codes see below).

Cluster	1	2	3	4	5	6
Vegetation type	1a	1b	2	3a	3b	4
Number of relevés	12	10	4	10	11	12
Aver. no. of species	9.5	13.1	12.8	14.0	12.5	13.8
Standard deviation	3.1	2.4	3.2	4.0	1.3	2.8
Differential species						
Cryptosepalum congolanum	IV	-	-	-	-	-
Oxystigma buchholzii	IV	-	-	-	-	-
Uapaca heudelotii	II	-	-	-	-	-
Treculia africana	III	-	-	-	-	-
Plagiosiphon multijugus	IV	I	-	-	-	-
Lasiodiscus marmoratus	-	II	-	-	-	-
Gilbertiodendron ogoouensis	III	III	-	-	I	-
Gilbertiodendron dewevrei	V	V	II	-	-	II
Anthonotha cf. *ferruginea*	-	-	III	-	-	-
Anthonotha macrophylla	I	-	III	I	-	-
Xylopia quintasii	-	-	IV	II	-	-
Calpocalyx dinklagii	-	II	IV	II	I	I
Grewia coriacea	-	-	IV	I	I	II
Cola rostrata	-	-	-	IV	V	II
Petersianthus macrocarpus	-	-	-	III	IV	I
Trichoscypha acuminata	-	-	-	-	II	I
Common species						
Santiria trimera	-	III	II	V	IV	V
Coula edulis	-	II	II	IV	II	IV
Polyalthea suaveolens	-	I	II	III	I	IV
Pentaclethra eetveldeana	-	I	II	II	I	III
Dialium pachyphyllum	II	II	-	I	II	I
Beilschmiedia sp.	I	II	II	II	I	-
Scorodophloeus zenkeri	-	-	II	IV	IV	V
Plagiostyles africana	-	II	-	I	IV	III
Centroplacus glaucinus	-	-	II	-	III	IV
Strombosia pustulata	-	I	-	III	V	III
Celtis tessmannii	-	I	-	II	I	I
Pausinystalia macroceras	-	I	II	-	III	II
Dichostemma glaucescens	I	I	-	-	II	I
Panda oleosa	I	I	III	-	-	III
Sorindeia nitidula	-	I	-	-	I	II
Trichilia welwitschii	-	-	II	I	I	-
Picralima nitida	-	-	II	I	I	-
Irvingia gabonensis	I	I	-	I	I	-
Indet.	II	II	III	I	II	II
Other species (excluding rare)						
Strombosia scheffleri	-	II	-	I	-	I
Heisteria parvifolia	-	II	-	I	-	I
Baphia buettneri	-	II	-	I	-	I
Mareyopsis longifolia	-	I	II	II	-	-
Carapa procera	-	I	-	I	I	I
Tetrabertinia bilobiata	-	I	-	I	-	II
Baphia pubescens	-	-	II	I	-	I
Pterocarpus soyauxii	-	I	II	-	-	I
Dacryodes klaineana	-	I	-	I	-	I
Dialium dinklagei	-	I	-	-	I	I
Afrostyrax lepidophyllus	-	-	-	II	II	I
Drypetes gossweileri	-	-	-	I	I	I
Garcinia gnetoides	-	I	-	I	-	I

Staudtia gabonensis	-	I	-	-	I	I
Xylopia parviflora	-	I	-	I	-	I
Pseudospondias sp.	-	I	II	-	-	-
Pachypodanthium staudtii	-	-	II	-	-	I
Markhamia tomentosa	-	-	II	-	I	-
Xylopia hypolampra	-	-	II	I	-	-
Alstonia boonei	-	-	II	I	-	-
Rauvolfia caffra	I	-	II	-	-	-
Sapium cornutum	-	-	II	-	-	I
Irvingia grandifolia	-	-	II	-	-	I
Ochthocosmus sp.	-	-	II	I	-	-
Psychotria sp.	I	-	II	-	-	-
Erythrophleum ivorensis	-	-	-	-	II	-
Pycnanthus angolensis	-	-	II	-	-	-
Terminalia suberba	-	-	II	-	-	-
Diospyros piscatoria	-	-	II	-	-	-
Maesopsis eminii	-	-	II	-	-	-
Nauclea diderichii	-	-	II	-	-	-
Rothmannia whitfieldii	-	-	II	-	-	-
Tricalysia biafrana	-	-	II	I	-	-
Grewia sp.	-	-	II	-	-	-
Celtis mildbraedii	-	-	II	-	-	-

Rare species

Albizia adianthifolia: 4,I; *Albizia ferruginea*: 4,I; *Angylocalyx sp.*: 1b,I; 3b,I; *Annonidium mannii*: 3b,I; 4,I; *Anopyxis klaineana*: 4,I; *Aphanocalyx cynometroides*: 1b,I; *Artabotrys sp.*: 3a,I; *Baikiea insignis*: 1b,I; *Baphia cf. leptostemma*: 1b,I; *Baphia sp.*: 1b,I; *Baphia sp.*: 1b,I; *Baphia sp.*: 3a,I; *Baphia sp.*: 1b,I; 3b,I; *Baphia sp.*: 1b,I; 3a,I; *Berlinia sp.*: 1b,I: *Blighia sp.*: 3a,I: *Bridelia micrantha*: 1b,I; *Caloncoba welwitschii*: 3a,I; *Camptostylis mannii*: 1a,I; 3a,I; *Celtis adolfi-friderici*: 1b,I; *Chytranthus sp.*: 3b,I, *Clerodendron sp.*: 4,I; *Coelocaryon preussii*: 3a,I, *Coffea sp.*: 1a,I; *Cola verticillata*: 1b,I; *Cola sp.*: 1b,I; *Cola sp*: 1b,I; *Cola sp.*: 1b,I; 3a,I; *Cola sp.*: 4,I; *Cola sp.*: 3a,I; *Combretum hornalioides*: 4,I; *Combretum sordidum*: 3a,I; 3b,I; *Combretum sp.*: 4,I; *Cylicodiscus gabunensis*; 3a,I; 4,I; *Cynometra sanagaensis*: 1a,I; *Dacryodes buettneri*: 4,I; *Dalbergia sp.*: 1a,I; 1b,I; *Dalhousiea africana*: 3b,I; *Detarium macrocarpum*; 1b,I; 4,I; *Dichapetalum choristilum*: 3b,I; *Didimosalpinx abbeokutae*: 1b,I; *Diospyros ferrea*: 1a,I; *Diospyros gilletii*: 1a,I; *Diospyros mannii*: 1b,I; 3a,I; *Discoglypremna caloneura*: 1b,I; *Distemonanthus benthamianus*: 3a,I; 3b,I; *Drypetes sp.*: 3b,I: 4,I; *Entandrophragma cylindricum*: 4,I; *Eribroma oblonga*; 3b,I; *Eriocoelon sp.*: 3a,I; *Gambeya boukokoensis*: 4,I; *Gambeya lacourtiana*: 3a,I; 3b,I; *Garcinia mannii*: 4,I; *Garcinia staudtii*: 3a,I; *Gardenia imperialis*: 1a,I; *Grewia pinnatifida*: 1a,I: 1b,I; *Grewia sp*: 3a,I: *Griffonia sp.*: 4,I; *Guarea cedrata*: 3a,I; *Klainedoxa gabonensis*. 3a,I; *Landolphia foretii*: 3b,I; *Lindackeria dentata*: 3a,I; 4,I; *Lonchocarpus sp*: 1a,I; *Lophira alata*: 1b,I; *Macaranga sp.*: 1a,I; *Magnistipula zenkeri*: 1a,I; *Mallotus oppositifolius*: 1a,I; *Mammea africana*: 1a,I; 3a,I; *Maprounea africana*: 1b,I; *Massularia acuminata*: 3a,I; *Microdesmis sp.*: 1a,I; *Milicia excelsa*: 3b,I; *Millettia bipindensis*: 1b,I; *Millettia laurentii*: 1b,I; 3b,I; *Millettia sp.*: 1a,I; *Monopetalanthus microphyllus*: 3b,I; 4,I; *Napoleonaea sp.*: 1a,I; *Nauclea pobeguinii*; 1a,I; *Nauclea vanderguchtii*: 1a,I; *Neuropeltis acuminata*: 1b,I; *Octolobus heteromerus*: 3a,I; *Odyenda gabonensis*: 3b,I; 4,I; *Omphalocarpum procerum*: 3b,I: *Oubanguia cf. africana*: 1a,I: 1b,I: *Pachypodanthium confine*: 4,I; *Pancovia sp.*: 3a,I; 4,I; *Parinari excelsa*: 1b,I; *Pausinystalia johimbe*: 3b,I; 4,I; *Piptostigma glabrescens*; 1b,I; *Plagiosiphon emarginatus*: 1a,I; *Porterandia cladantha*: 3a,I; *Pterocarpus sp.*: 1a,I; *Pterygota bequaertii*: 4,I; *Rhaphiostylis sp.*: 3a,I; *Rauvolfia letouzeyi*: 3b,I; *Rinorea kamerunensis*: 3b,I; *Rinorea subsessilis*: 3b,I; *Rinorea welwitschii*: 1b,I; *Sorindeia sp.*: 1b,I; *Sorindeia sparanoi*: 1a,I; *Strephonema mannii*: 1b,I; *Strychnos campicola*: 1a,I; *Synsepalum longecuneatum*: 1b,I; 4,I; *Syzygium sp.*: 4,I; *Tabernaemontana crassa*: 3b,I; *Tessmannia anomala*: 1a,I; *Testulea gabonensis*: 4,I; *Thomandersia laurifolia*: 4,I; *Trichilia monadelpha*: 1a,I, *Trichoscypha sp.*: 3a,I; *Xylopia aethiopica*: 4,I; *Xylopia letestui*: 1b,I; 3a,I; *Xylopia pinaertii*: 3a,I; *Xylopia sp.*: 4,I; *Xylopia staudtii*: 3b,I.

Frequencies in 5 classes

-	= species not present in the relevés of the cluster
+	= species present in 1-5% of the relevés
I	= species present in 6-20% of the relevés
II	= species present in 21-40% of the relevés
III	= species present in 41-60% of the relevés
IV	= species present in 61-80% of the relevés
V	= species present in 81-100% of the relevés

ce are lacking. These will be necessary to confirm the existence of such types and make it possible to interpret the forest types in an ecological sense. Doing so the types can possibly be used for much wider areas. Through species composition these types can only be distinguished as primary or secondary types.

Although not a classical way of making vegetation relevés and typology, whereby for each species in a homogenous sample plot a cover/abundance code is given (KENT & COKER 1992), recording presence/absence plus relative abundance according to the number of individual trees in adjacent plots along a transect, has proved by this study to be a suitable method for defining local forest types (communities). Enumerating cover/abundance of all species of a homogeneous sample plot in rain forest is very time consuming. It should be noted that the present study was initially not meant for making a vegetation classification but a general forest inventory.

The numbet of 100 m plots (59) may be considered too small to include the great diversity of the forest. More plots are needed and would surely result in clearer differentiation between the recognized types and may reveal additional types. The size of the 100 m plots (100 × 5 m) might be questioned. For relevés in rain forest, enumerating only trees above a certain dbh larger plots are often used. It is beyond the scope of this study to debate the issue of sample plot size and minimum area. The reader is referred to amongst others, HOMMEL (1987, 1990), DE ROUW (1991) and DUIVENVOORDEN & LIPS (1995).

The forest types as distinguished in this survey show that within the general forest classification of CABALLÉ (1978) for eastern Gabon, various associations can occur. CABALLÉ recognized 2 types: a "forêt dense humide sempervirente" with *Scyphocephalum ochocoa*, *Pycnanthus angolensis*, *Pentaclethra eetveldeana*, *Celtis spp.*, *Gilletiodendron pierreanum*, and *Gilbertiodendron dewevrei*; a "forêt dense à tendance semi-caducifoliée" with *Pycnanthus angolensis*, *Pentaclethra eetveldeana*, *Terminalia superba* and *Triplochiton scleroxylon*. These correspond more or less with Types B and E found in the Minkebé area. However, in the Minkébé survey *Scyphocephalum ochocoa*, *Gilletiodendron pierreanum* and *Triplochiton scleroxylon* were not found.

GÉRARD (1960) regarded the *Gilbertiodendron dewevrei* forest in the Uele region (Congo) as a climax vegetation, since it was a self regenerating stable population of this species. ÉVRARD (1968) regarded single dominant forest as the climax type since the dominants, besides being able to regenerate in their own shade, can also invade mixed moist semi-evergreen rain forest, which is usually deficient in regeneration of its own upper canopy species. This contrasts with the opinion of LETOUZEY (1983) who regards the *Gilbertiodendron dewevrei* forests as relicts of a formerly more extensive *Gilbertiodendron* forest, that are steadily being invaded by the surrounding mixed forest species, due to natural or human causes. ÉVRARD and LETOUZEY agree that possibly recent climatic change has been too rapid to allow the *Gilbertiodendron dewevrei* forest to achieve its maximum potential range during those climatic phases of the Pleistocene most favourable for its expansion. The present study reveals that GÉRARD's view on the *Gilbertiondron* forest also applies to the Minkébé region.

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REFERENCES

AUBRÉVILLE A. 1967.—La forêt primaire des montagnes de Bélinga. *Biologia Gabonica* 3: 95-112.

CABALLÉ G. 1978.—Essai sur la géographie forestière du Gabon. *Adansonia*, sér. 2, 17: 425-440.

DUIVENVOORDEN J.F. & LIPS J.M. 1995.—*A land-ecological study of soils, vegetation, and plant diversity*

in Colombian Amazonia. Tropenbos Series 12. The Tropenbos Foundation, Wageningen.

ÉVRARD C. 1968.—*Recherches écologiques sur le peuplement forestier des sols hydromorphes de la Cuvette centrale Congolaise*. I.N.É.A.C., série scientifique 110, Congo.

FLORENCE J. & HLADIK A. 1980.—Catalogue des Phanérogames et des Ptéridophytes du Nord-Est du Gabon (Sixième liste). *Adansonia*, sér. 2, 20: 235-253.

GÉRARD Ph. 1960.—*Étude écologique de la forêt dense à Gilbertiodendron dewevrei dans la région de l'Uele*. I.N.É.A.C., série scientifique 87, Congo.

HALLÉ N. 1964.—Liste des Phanérogames et des Ptéridophytes des environs de Makokou, Kemboma et Bélinga. *Biologia Gabonica* 1: 41-46.

HALLÉ N. 1965.—Seconde liste de Phanérogames et Ptéridophytes du N-E du Gabon (Makokou, Bélinga et Mékambo). *Biologia Gabonica* 1: 337-344.

HALLÉ N. & LE THOMAS A. 1967.—Troisième liste de Phanérogames du N-E du Gabon (Makokou, Bélinga et Mékambo). *Biologia Gabonica* 3: 113-120.

HALLÉ N. & LE THOMAS A. 1970.—Quatrième liste de Phanérogames et Ptéridophytes du N-E du Gabon (Bassin d'Ivindo). *Biologia Gabonica* 6: 131-138.

HALLÉ N., LE THOMAS A. & GAZEL M. 1967.—Trois relevés botaniques dans les forêts de Bélinga (N.-E. du Gabon). *Biologica Gabonica* 3: 3-16.

HILL M.O. 1979.—*TWINSPAN: A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes*. Cornell University, New York.

HLADIK A. & HALLÉ N. 1973.—Catalogue des Phanérogames du Nord-Est du Gabon (Cinquième liste). *Adansonia*, sér. 2, 13: 527-544.

HOMMEL P.W.F.M. 1987.—*Landscape-ecology of Ujung-Kulon (West Java, Indonesia)*. PhD thesis, privately published.

HOMMEL P.W.F.M. 1990.—A phytosociological study of a forest in the humid tropics (Ujung Kulon, West Java, Indonesia. *Vegetatio* 89: 39-54.

KENT M. & COKER P. 1992.—*Vegetation description and analysis*. CRC Press, USA.

LETOUZEY R. 1983.—Quelques exemples camerounais de liaison possible entre phénomènes géologiques et végétation. *Bothalia* 14: 739-744.

REITSMA J.M. 1988.—*Végétation forestière du Gabon/Forest vegetation of Gabon*. (Technical Series 1) The Tropenbos Foundation, Ede.

ROUW A. de 1991.—*Rice, weeds and shifting cultivation in a tropical rain forest. A study of vegetation dynamics*. PhD thesis, privately published.

SAINT AUBIN G. de 1963.—*La forêt du Gabon*. CTFT, Nogent-sur-Marne.

SCHAMINÉE J.H.J., STORTELDER A.H.F. & WESTHOFF V. 1995.—*De vegetatie van Nederland. Deel 1. Inleiding tot de plantensociologie-grondslagen, methoden en toepassingen*. Opulus Press, Uppsala, Leiden.

STEEL E.A. 1992.—*Une proposition au gouvernement gabonais sur l'aménagement et la conservation d'une zone protégée dans le Nord-Est du Pays*. WWF program, paper no. 4.

VALKENBURG J.L.C.H. VAN 1990.—*Final report floristic inventory and vegetation survey of the Minkébé area*. Submitted to C.M. WILKS, project coordinator.

WHITE F. 1983.—*The vegetation of Africa: a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa*. Unesco, Paris.

WHITE L. & ABERNETHY K. 1996.—*Guide de la végétation de la Réserve de la Lopé, Gabon*. Ecofac, Gabon.

APPENDIX: NEW RECORDS FOR NORTH EAST GABON

Based on MINKÉBÉ collections present at Herbarium Vadense (WAG) and fully documented there. Complete species list (based on VAN VALKENBURG 1990) published as appendix 2b in STEEL (1992). Additional collections from december 1990 have been included for the present list.

Acanthaceae
Justicia tenella (Nees) T. Anderson: W 508
Phaulopsis poggei (Lindau) Lindau: W 427
Rhinacanthus virens (Nees) Milne-Redh.: AM 7; W 153
Alismataceae
Ranalisma humile (Kunth) Hutch.: W 144; Wieringa 614
Anacardiaceae
Sorindeia sparanoi De Wild.: E 32
Annonaceae
Monanthotaxis klainei Pierre ex Engl. & Diels var. *lastoursvillensis* (Pellegr.) Verdc.: AM 26

Pachypodanthium confine Engl. & Diels: C 324, 455; W 65
Uvaria versicolor Pierre ex Engl. & Diels: AM 46
Xylopia parviflora (A. Rich.) Benth.: C 364, 716
Xylopia pynaertii De Wild.: C 789; E 288
Apocynaceae
Baissea baillonii Hua: R 141
Landolphia foretii Jum.: C 112
Rauvolfia caffra Sond.: E 26, 347
Rauvolfia letouzeyi Leeuwenb.: E 270
Tabernaemontana eglandulosa Stapf: W 509
Begoniaceae
Begonia mildbraedii Gilg: W 200, 436
Begonia scutifolia Hook. f.: W 221
Begonia sessilifolia Hook. f.: W 278
Begonia subscutata De Wild.: AM 77; W 171, 361; Wieringa 539, 581
Bombacaceae
Rhodognaphalon brevicuspe (Sprague) Roberty: A 721
Caesalpiniaceae
Amphimas pterocarpoides Harms: A 72, 467
Anthonotha cf. *ferruginea* (Harms) J. Léonard: C 207
Baphiopsis parviflora Benth. ex Baker: W 57; X 237; Y 6, 13
Cynometra simagaensis Aubrév.: AM 73; E 87; Wieringa 542
Cynometra schlechteri Harms: W 496
Daniellia oblonga Oliv.: A 102
Erythrophleum suaveolens (Guill. & Perr.) Brenan: C 686; S 195
Gilbertiodendron ogouense (Pellegr.) J. Léonard: AM 72; C 33, 68, 89, 118, 283, 367, 371, 387, 484, 492; E 18; V 1, 140, 180, 231
Guibourtia tessmannii (Harms) J. Léonard: A 77
Julbernardia seretii (De Wild.) Troupin: B 83
Monopetalanthus evrardii P. Bamps: A 50; B 43; C 27, 87, 279, 286; E 16, 69, 139, 167, 182; S 41; W 438
Monopetalanthus letestui Pellegr.: A 360, 609
Oxystigma buchholzii Harms: A 1; AM 45; E 2; W 3; Wieringa 540 Z 18
Plagiosiphon emarginatus (Hutch. & Dalz.) J. Léonard: E 163, 181; S 93; W 591
Plagiosiphon multijugus (Harms) J. Léonard: C 3, 37, 347; E 23, 63, 66. 117; V 2; W 642; X 10
Plagiosiphon multijugus (Harms) J. Léonard var. *gracilis* Pellegr.: C 32
Stemonocoleus micranthus Harms: B 158
Tessmannia anomala (Micheli) Harms: B 35, 91; C 8
Tetraberlinia bifoliolata (Harms) Hauman: C 82, 299, 447, 483; E 287
Capparaceae
Cleoma afrospinosa Iltis: AM 18; W 127
Chrysobalanaceae
Magnistipula zenkeri Engl.: AM 70; E 110, 112, 114
Combretaceae
Combretum cauchipetalum Engl. & Diels: E 108, 148
Combretum demeusei De Wild.: W 409, 502
Combretum homalioides Hutch. & Dalz.: C 99
Combretum multinervium Exell: W 29
Combretum sordidum Exell: W 227
Strephonema mannii Hook. f.: E 115
Commelinaceae
Commelina africana L.: Wieringa 644
Floscopa africana (P. Beauv.) C.B. Clarke: W 145
Floscopa glomerata (Willd. ex J.A. & J.H. Schult.) Hassk.: W 448
Palisota ambigua (P. Beauv.) C.B. Clarke: Wieringa 640
Compositae
Adenostemma perrottetii DC.: W 115, 333
Ethulia conyzoides L. f.: W 116
Melanthera scandens (Schum. & Thonn.) Roberty: W 380, 449; Wieringa 584; Y 12
Struchium sparganophora (L.) O. Kuntze: W 344

Vernonia stellulifera (Benth.) Jeffrey: W 240
Convolvulaceae
Neuropeltis cf. *velutina* Hallier f.: S 51
Cucurbitaceae
Zehneria gilletii (De Wild.) E. Jeffrey: W 497; Wieringa 659; Y 11, 21
Cyperaceae
Bulbostylis filamentosa (Vahl) C.B. Clarke: W 237
Cyperus compressus L.: W 99
Cyperus digitatus Roxb. subsp. *acericomus* (Spreng.) Kük.: W 139, 381
Cyperus laxus Lam. subsp. *buchholzii* (Boeck) Lye: W 239
Cyperus remotispicatus Hooper: W 455
Fuirena umbellata Rottb.: W 454
Hypolytrum senegalense A. Rich.: AM 79; V 104; W 131
Mapania amplivaginata K. Schum.: AM 59; W 432
Dichapetalaceae
Dichapetalum choristilum Engl.: C 173; R 29; S 5, 87, 219
Dichapetalum lujae De Wild. & T. Durand: S 43, 70
Dichapetalum minutiflorum Engl.: S 61
Dipterocarpaceae
Ancistrocladus barteri Scott-Elliot: R 80, S 231
Ebenaceae
Diospyros alboflavescens (Gürke) F. White: V 95
Diospyros ferrea (Willd.) Bakh.: AM 15; E 142; V 122; W 11, 341
Diospyros sanza-minika A. Chev.: AM 38
Euphorbiaceae
Antidesma venosum Tul.: W 532, 548
Antidesma vogelianum Müll. Arg.: W 120, 150, 188, 505; Wieringa 607; Z 34
Bridelia micrantha (Hochst.) Baill.: C 360
Cleistanthus letouzeyi J. Léonard: E 136, 154; W 377
Erythrococca anomala (Juss. ex Poir.) Prain: Wieringa 590
Euphorbia grandifolia (Haw.) Croizat: W 256
Keayodendron bridelioides (Mildbr. ex Hutch. & Dalz.) Leandri: A 69; C 227, 261, 449
Maprounea africana Müll. Arg.: C 404
Microdesmis puberula Hook. f. ex Planch.: R 144; S 104
Oldfieldia africana Benth. & Hook. f.: A 660, 663, 712
Pentabrachion reticulatum Müll. Arg.: C 179
Phyllanthus diandrus Pax: R 138
Pycnocoma cornuta Müll. Arg.: W 34
Flacourtiaceae
Flacourtia vogelii Hook. f.: W 480
Homalium abdessammadii Aschers. & Schweinf.: W 476
Homalium africanum (Hook. f.) Benth.: AM 56
Oncoba mannii Oliv.: Wieringa 562, 636
Scottellia klaineana Pierre: A 68
Gramineae
Guaduella marantifolia Franch.: R 6
Isachne kiyalensis Robyns: W 456
Leptaspis zeylanica Nees ex Steud.: Wieringa 551
Panicum mueense Vanderyst: Wieringa 573
Guttiferae
Garcinia mannii Oliv.: E 306
Garcinia staudtii Engl.: AM 14; C 566
Psorospermum tenuifolium Hook. f.: W 262
Hippocrateaceae
Salacia alata De Wild.: R 32; S 150
Salacia leptoclada Tul.: Wieringa 563
Icacinaceae
Alsodeiopsis staudtii Engl.: Wieringa 651
Desmostachys tenuifolius Oliv. var. *tenuifolius*: Wieringa 645

Icacina mannii Oliv.: R 146; S 73
Pyrenacantha vogeliana Baill.: S 145
Irvingiaceae
Desbordesia glaucescens (Engl.) Tiegh.: A 402
Irvingia excelsa Mildbr.: A 472
Klainedoxa microphylla (Pellegr.) A. Gentry: W 299a
Klainedoxa trillesii Pierre ex Tiegh.: A 543
Labiatae
Hoslundia opposita Vahl: W 568
Platostoma africanum P. Beauv.: W 358
Solenostemon mannii (Hook. f.) Baker: W 447
Liliaceae
Chlorophytum laxum R. Br.: W 149
Chlorophytum orchidastrum Lindl.: W 387
Dracaena mannii Baker: A 289
Dracaena viridiflora Engl. ex Krausse: D 63; W 255
Linaceae
Hugonia afzelii R. Br. ex Planch.: W 283
Loganiaceae
Strychnos boonei De Wild.: V 55
Strychnos congolana Gilg: R 166
Strychnos staudtii Gilg: V 183
Strychnos tchibangensis Pellegr.: W 396
Loranthaceae
Globimetula opaca (Sprague) Danser: W 596, 605
Phragmanthera capitata (Spreng.) Balle: Wieringa 593
Tapinanthus platyphyllus (Hochst. ex A. Rich.) Danser: W 544
Viscum congolense De Wild.: AM 64; F 4; W 68
Luxemburgiaceae
Testulea gabonensis Pellegr.: A 801; C 330
Malvaceae
Hibiscus rostellatus Guill. & Perr.: W 126
Marantaceae
Halopegia azurea (K. Schum.) K. Schum.: W 151; Wieringa 545
Marantochloa congensis (K. Schum.) J. Léonard & Mull.: V 188
Marantochloa leucantha (K. Schum.) var. *leucantha*: Wieringa 585
Marantochloa purpurea (Ridl.) Milne-Redh.: AM 1; W 313; X 11
Sarcophrynium brachystachys (Benth.) K. Schum.: W 17
Melastomataceae
Calvoa orientalis Taubert: W 243
Guyonia ciliata Hook. f.: W 419
Memecylon viride Hutch. & Dalz.: W 343
Ochthocharis dicellandroides (Gilg) C. Hansen & Wickens: W 452
Tristemma littorale Benth. subsp. *biafranum* Jacq.-Fél.: AM 43; W 158
Meliaceae
Carapa procera DC.: C 77
Entandrophragma congoense (De Wild.) A. Chev.: B 243, 313
Entandrophragma cylindricum (Sprague) Sprague: A 63; B 40; C 439
Guarea cedrata (A. Chev.) Pellegr.: B 69; C 256
Guarea thomsonii Sprague & Hutch.: A 469; B 74
Trichilia monadelpha (Thonn.) J.J. de Wilde: E 104, 361; W 660; X 236; Z 25
Trichilia tessmannii Harms: A 21, 634; X 236; Z 25
Trichilia welwitschii C. DC.: AM 31; C 687; E 268
Turraeanthus africanus (Welw. ex C. DC.) Pellegr.: A 435
Mimosaceae
Albizia zygia (DC.) J.F. Macbr.: W 75
Newtonia duparquetiana (Baill.) Keay: W 526, 550
Parkia filicoidea Welw. ex Oliv.: A 117, 397

Moraceae
Antiaris africana Engl.: A 643
Dorstenia mannii Hook. f.: W 223, 274, 637, 645
Ficus adolfi-friderici Mildbr.: V 62
Ficus pseudomangifera Hutch.: W 8
Milicia excelsa (Welw.) C.C. Berg: A 78; C 700
Nymphaeaceae
Nymphaea lotus L.: W 606
Ochnaceae
Ouratea affinis (Hook. f.) Engl.: W 122, 352; X 72
Ouratea calantha Gilg: W 95, 469; X 146
Ouratea congesta (Oliv.) Engl.: AM 66; R 99; S 171; W 41, 85, 94
Ouratea elongata (Oliv.) Engl.: W 204; Wieringa 587
Olacaceae
Strombosia scheffleri Engl.: A 104; C 262, 335; E 201; V 93; W 491
Orchidaceae
Bulbophyllum cocoinum Lindl.: Wieringa 580
Genyorchis apetala (Lindl.) J.J. Vermeulen: Wieringa 538
Papilionaceae
Airyantha schweinfurthii (Taub.) Brummitt: S 132
Baphia buettneri Harms subsp. *hylophila* (Harms) Soladoye: AM 9; W 88
Baphia leptostemma Baill.: C 76
Baphia pubescens Hook. f.: AM 35; C 211, 423; F 6; W 58
Baphiastrum brachycarpum Harms: S 44
Baphiopsis parviflora Benth. ex Baker: Wieringa 547
Millettia bipindensis Harms: AM 49, 69; C 352; E 217;W 152, 493; X 100; Z 30
Pontederiaceae
Heteranthera callifolia Rchb. ex Kunth: AM 24; W 141
Pteridophytae
Antrophyum mannianum Hook.: V 185; W 195
Asplenium jaundense Hieron.: V 136; W 347
Blotiella currori (Hook.) Tryon: W 471
Diplazium sammatii (Kuhn) C. Chr.: W 146; Wieringa 619
Polypodium owariense Desv.: AM 12; W 348; X 108
Trichomanes ballardianum Alston: V 72
Trichomanes mannii Hook.: V 73; W 369
Triplophyllum gabonense Holttum: R 4; S 19
Triplophyllum vogelii (Hook.) Holttum: W 228, 446
Rhamnaceae
Maesopsis eminii Engl.: E 354
Rubiaceae
Belanophora arborescens Hoyle: W 285
Commitheca liebrechtsiana (De Wild. & T. Durand) Bremek.: W 305, 478
Didimosalpinx abbeokutae (Hiern) Keay: E 179
Geophila involucrata Schweinf. ex Hiern: S 31; W 417
Hymenocoleus globulifer Robbrecht: W 166
Hymenocoleus hirsutus (Benth.) Robbrecht: R 36; S 72, 109; W 279, 418bis, 463
Hymenocoleus nervopilosus Robbrecht var. *orientalis* Robbrecht: W 315, 418
Hymenocoleus subipecacuanha (K. Schum.) Robbrecht: AM 61; R 5; W 202
Ixora guineensis Benth.: W 71, 197; X 186
Mitragyna stipulosa (DC.) O. Kuntze: A 604
Oldenlandia goreensis (DC.) Summerh.: W 444
Pseudosabicea medusula (Wernham) N. Hallé: AM 29; W 55, 163
Rothmannia whitfieldii (Lindl.) Dandy: E 338
Sabicea dinklagei K. Schum.: W 378
Tricalysia vadensis Robbrecht: R 128, 232; W 420
Sapindaceae
Allophylus cobbe (L.) Raeusch.: R 254; W 483
Deinbollia maxima Gilg: W 400

Sapotaceae
Gambeya africana (Don ex Baker) Pierre: W 295
Manilkara argentea Pierre ex Dubard: W 119
Tieghemella africana Pierre: A 659
Tridesmostemon omphalocarpoides Engl.: A 640
Scytopetalaceae
Oubanguia laurifolia (Pierre) Tiegh.: Y 19
Simaroubaceae
Odyenda gabonensis (Pierre) Engl.: C 318, 782; S 139
Sterculiaceae
Eribroma oblonga (Mast.) Bodard: A 25; C 194
Leptonychia echinocarpa K. Schum.: Wieringa 621
Leptonychia lasiogyne K. Schum.: F 5
Leptonychia multiflora K. Schum.: AM 37; R 64; W 13, 13bis, 49, 110
Sterculia subviolacea K. Schum.: W 1
Thymelaeaceae
Dicranolepis baertsiana De Wild. & T. Durand: W 63, 181
Dicranolepis vestita Engl.: AM 8, 23; W 62, 101
Tiliaceae
Duboscia viridiflora (K. Schum.) Mildbr.: C 186
Grewia pinnatifida Mast.: C 54; E 165
Ulmaceae
Celtis adolfi-friderici Engl.: A 126; AM 55
Urticaceae
Laportea ovalifolia (Schum. & Thonn.) Chev.: W 51, 401
Violaceae
Rinorea cerasifolia M. Brandt: W 102, 160, 277, 339
Rinorea kamerunensis Engl.: D 16
Rinorea longicuspis Engl.: Wieringa 546
Rinorea mildbraedii M. Brandt: Wieringa 561
Rinorea subsessilis M. Brandt: AM 2; C 618; D 6; R 8; W 467
Rinorea welwitschii (Oliv.) O. Kuntze: C 83; R 239; W 258
Vochysiaceae
Erismadelphus exsul Mildbr.: A 184
Zingiberaceae
Aframomum limbatum (Oliv. & Hanb.) K. Schum.: W 443; Wieringa 554
Renealmia cincinnata (K. Schum.) Baker: W 92

Explanation of prefixes in Minkébé collection: A, B: voucher specimen transect trees > 70 cm dbh; C, E: voucher specimen transect trees > 10 cm dbh; R, S, V, X, Y, Z: voucher specimens subplots; AM: André Mounga zi; D: Dibata; F: Mondjo, Obiang; W: Wilks.

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